Climate Vulnerability and Impact Assessments Can Provide Useful Insights and Guidance-Now

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The climate change issue is traditionally subdivided into three key questions:

- 1. How is the climate expected to change and are we already seeing the early signs of these changes?
- 2. What are the environmental and societal impacts that are expected, and to what extent can adaptation ameliorate the projected negative consequences?
- 3. What are the options for limiting the human-caused factors inducing these changes and how rapidly and economically can they be implemented?

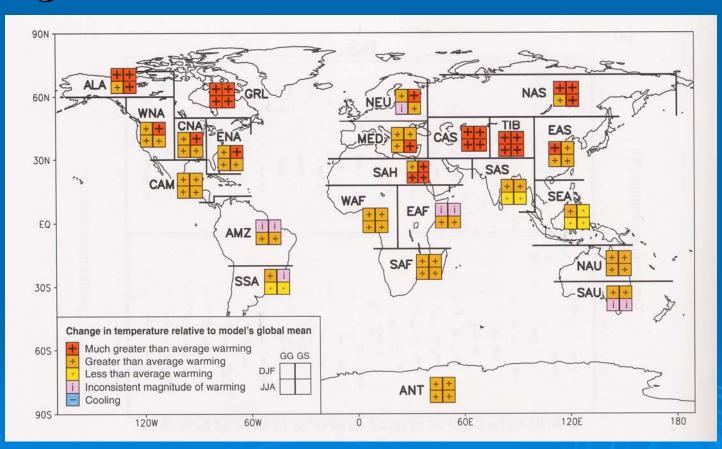
Answering the key questions is complicated by several unusual factors

- The changes in climate, the impacts of the changes, and the implementation of options all have centurylong time horizons
- Projection of a range of possibilities (rather than a definitive prediction) is all that can be expected given the complexity of society and the environment and the chaotic aspects of the climate
- The causes, impacts, and control of the issue are necessarily international, introducing many situations and perspectives that can affect and complicate the outcome

Under the guidance of the UNFCCC, the IPCC carries out periodic assessments summarizing the state of expert understanding of the answer to each of the three questions

- Technical chapters and a technical summary provide expert perspectives on the levels of confidence and relevant uncertainties
- The Summary for Policymakers and Synthesis Report summarize understanding in terms of the relative likelihood and risk
- The representatives of some 150+ countries make up the UNFCCC and the periodic assessments have been endorsed by over a score of major national academies

Climate models are providing increasingly consistent projections of the expected changes in climate at the sub-continental scale



Model simulations of the global pattern of warming suggest greater warming in mid- to high latitudes, over land, and during the winter

The IPCC projects intensifying changes in many important climatic measures during the 21st century

- ➤ The global average of changes in annual average surface temperature is projected to increase by 1.4 to 5.8°C
- Total annual precipitation is projected to increase in many regions, with the largest changes occurring for the most intense convective systems.
- An increased rate of evaporation will more rapidly lead to soil moisture stress and drought, especially where precipitation decreases
- Sea level is projected to rise by 9 to 88 cm, augmented or diminished by local influences

The most likely changes are considered to be toward the middle of these ranges

Impact assessments evaluate the potential vulnerability to scenarios of projected changes in climate

- The climate change scenarios are not predictions--they are intended to be plausible indications of the range and type of changes that could occur
- A range of approaches can be used to generate plausible scenarios for investigating vulnerability of environmental and societal systems:
 - Recurrence of past conditions (perhaps augmented)
 - Changes generated by global and/or regional models
 - Consideration of thresholds and evaluation of the potential for their occurrence

The US National Assessment took special steps to enhance the regional representativeness of the model-based scenarios

- Changes from global climate models were used to increment highly resolved climatologies to retain variations in climate due to mountains, coastal environments, etc. This tends to diminish problems due to systematic errors in the models
- Results from two models were used in most studies as a step toward spanning the range of plausible conditions needed to evaluate potential vulnerability
- Where possible, results from more than two models were used, and in some cases regional models were used as an alternative approach to refining spatial resolution
- Limitations were more affected by the limited budget resources for modeling than by the state of models

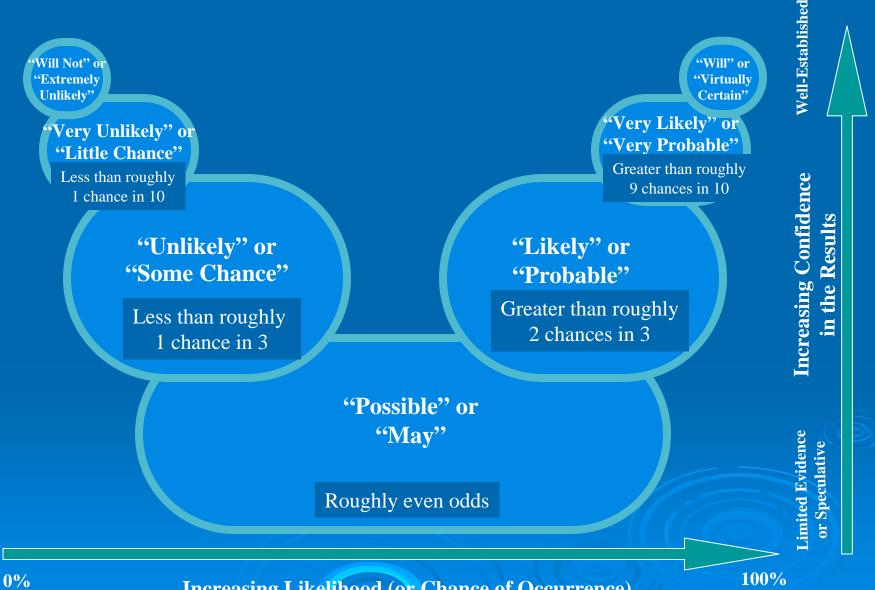
The wide range of possible changes in climate does not directly affect impact assessments of potential vulnerability

- Many combinations of future emissions and of climate sensitivity lead to similar degrees of climate change, especially because of the inertia of the climate system and the momentum of past activities
- Variations from central values mainly imply somewhat earlier or later onset of the changes--not changes in their character, pattern or interrelationships
- To repeat, the impact assessments are not predictions-they are explorations of potential vulnerability that lead to generalized projections

Recognizing that only generalized projections are possible, specialized lexicons have been developed to roughly indicate levels of likelihood and confidence

- IPCC's Working Group I used a 7-term lexicon that had very welldefined boundaries
- IPCC's Working Group II used a 5 term lexicon that also provided an indication of how well a finding was established
- The US National Assessment used a 5-term lexicon that recognized limitations in knowledge by having fuzzy boundaries
- The Arctic Climate Impact Assessment augmented the lexicon used for the US National Assessment by adding a terms covering inevitable outcomes
- The IPCC is now working to refine its approach and encourage broader and more consistent application

A Conceptual Lexicon of Relative Confidence and Likelihood



The US National Assessment's key findings* ended up not being tightly dependent on the details of the climate scenarios

- 1. Increased warming **is** projected across the US
- 2. Climate changes and impacts will vary regionally
- 3. Many ecosystems are highly vulnerable, and the goods and services lost through their disappearance or fragmentation are **likely** to be costly or impossible to replace
- 4. Water **is** an issue in every region, but the nature of the vulnerabilities varies
- 5. The agriculture sector is **likely** to be able to adapt to climate change, but the gains will not be uniform across the nation
- 6. Forest productivity is **likely** to increase over the next several decades, but changes in fire, insects, droughts, disease, etc. **will possibly** decrease long-term productivity
- 7. Increased damage **is** projected for coastal and permafrost areas
- 8. Adaptation is **likely** to help protect much of the US population from adverse health outcomes, presuming our nation's public health and community infrastructure are enhanced
- 9. Other stresses such as air and water quality are **very likely** to be magnified by climate change
- 10. Significant uncertainties remain and surprises are likely

^{*}The statements of the the key findings have been shortened and paraphrased here to illustrate application of the lexicon; for complete text, see www.usgcrp.gov/usgcrp/nacc/default.htm

The US Government's official communication to the UNFCCC focused primarily on the most likely consequences

- "Very Likely" Impacts*
 - Reduced mountain snowpack, altering timing and amount of spring runoff, and enhancing warm season recreation
 - Increased heat index and frequency of heat waves
 - Shifted locations and areas of wildlife habitat
 - Increased timber inventories due to increased forest productivity
 - Reduced lake, river, and sea ice, altering stratification and shipping season
 - Increased loss of coastal wetlands

- "Likely" Impacts*
 - Minimum temperatures rise more than maximum temperatures
 - Loss of many sensitive ecosystems, such as alpine forests and barrier islands
 - Shifting of desert ecosystems in the Southwest into grassland or shrub systems, accompanied by increased frequency of fires
 - Increased overall agricultural productivity as a result of adaptation by changing planting dates and varieties
 - More rapid dispersion of invasive (weedy) species into disturbed habitats

*Selected examples drawn from Chapter 6 of the *US Climate Action Report 2002*. Full text available at http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsUSClimateActionReport.html

Even with the limitations in available information, particular regions and sectors can enhance the basis of their long-term planning using assessment results

- California has recognized that global warming is virtually certain to lead to a higher snowline and reduced springtime snowpack, affecting water resource planning
- Coastal states recognize that the amount of sea level rise is very likely to be much larger during the 21st century, and that early planning for retreat or coastal defense can reduce the likely long-term costs and provide time for addressing the very likely loss of coastal wetlands
- Projected shifts in land cover and its likely future condition can be incorporated into land and wildlife management plans
- Changes in timing of open water can be utilized by shipping companies and fishing fleets to better schedule access

Impact assessments can currently provide useful information to important stakeholders--and more can be done

- Well-designed impact assessments should involve stakeholders in a joint learning process, helping the stakeholders to gain the understanding they need of the likelihood and confidence levels of available information for use, at their discretion, in their long-term planning
- The most important national level step that could be taken would be to insert a requirement that environmental impact statements consider the resilience of the planned action and its effects upon long-term climatic and environmental change
- The intensification of regional and sectoral impact assessment activities would be required so that interested decision-makers would have the understanding and information needed to balance the likelihood and risks of future changes with an incremental costs and actions, especially in the context of dealing with other stresses and issues